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VI. When  $x = 143.27$  then  $y < 0$  and  $A = 0$ . Since  $x < 192.5$ ,  $(2x + y)2x > 0$  by (5).

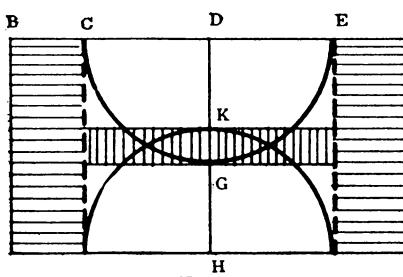


FIG. 12.

$$102.67 < x < 192.5, y < -x.$$

and Fig. 14 is representative.

In V, VI, VII, the race-track is partly positive and partly negative. In equation (2) the  $2\pi x$  is positive and the  $2y$  is negative as is indicated in the figures by the solid and dotted parts of the track.

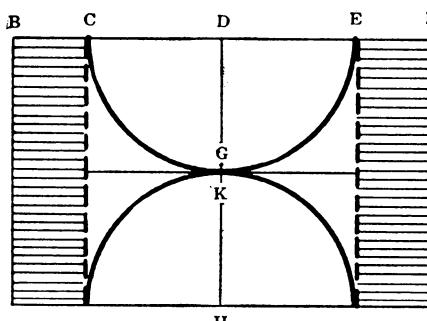


FIG. 13.

$$x = 192.5, y = -2x.$$

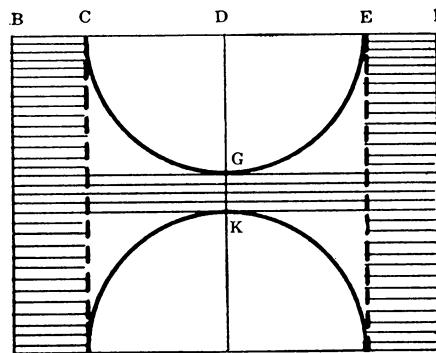


FIG. 14.

$$192.5 < x + \infty, y < -2x.$$

Also solved by HORACE OLSON, S. E. URNER, PAUL CAPRON, and J. W. BALDWIN.

### MECHANICS.

#### 336. Proposed by C. N. SCHMALL, New York City.

An inclined plane, length  $l$ , makes an angle  $\phi < (\frac{1}{4}\pi)$  with the horizontal plane through its foot. From its foot, a body is projected upward along the plane, with a velocity equal to that of a falling body at the height  $h$ , so as to pass over the top and strike the horizontal plane at the maximum distance,  $x$ , from the foot of the inclined plane. Show by methods of the calculus that  $x = h/(\sin \phi \cos \phi)$ , and that the corresponding value of  $l$  is  $(2h \cot 2\phi)/\cos \phi$ .

### SOLUTION BY THE PROPOSER.

Let  $v_1$  = velocity at time of projection;  $v$  = velocity on reaching top of plane;  $a$  = height of inclined plane;  $x_1$  = horizontal distance traversed by body after leaving plane.

Then, by the given conditions, we have

$$v_1^2 = 2gh, \quad (1)$$

$$a = l \sin \phi, \quad (2)$$

$$v^2 = 2g(h - a), \quad (3)$$

$$x = x_1 + a \cot \phi, \quad (4)$$

or,

$$x_1 = x - a \cot \phi. \quad (5)$$

Now taking the top of the inclined plane as the origin, the equation of the path of the body is

$$\begin{aligned} -a &= x_1 \tan \phi - \frac{g}{2} \frac{x_1^2}{v^2 \cos^2 \phi} \\ &= x_1 \tan \phi - \frac{g}{2} \frac{x_1^2}{2g(h - a) \cos^2 \phi} \end{aligned} \quad (6)$$

by equation (3). Whence,

$$(h - a)(a + x_1 \tan \phi) = \frac{x_1^2}{4 \cos^2 \phi}$$

which, putting  $x - a \cot \phi$  for  $x_1$  from (5), becomes

$$(h - a)x \tan \phi = \frac{(x - a \cot \phi)^2}{4 \cos^2 \phi}.$$

Hence,

$$x^2 - 2x(a \cot \phi \cos 2\phi + h \sin 2\phi) + a^2 \cot^2 \phi = 0, \quad (7)$$

where  $x$  is to be made a maximum.

Differentiating with respect to  $a$ , we get

$$\{x - (a \cot \phi \cos 2\phi + h \sin 2\phi)\} \frac{dx}{da} - x \cot \phi \cos 2\phi + a \cot^2 \phi = 0. \quad (8)$$

Hence,

$$\frac{dx}{da} = 0, \quad \text{if} \quad x = a \frac{\cot \phi}{\cos 2\phi}.$$

Putting this value of  $x$  in (7) and reducing, we get

$$a = h \frac{\cos 2\phi}{\cos^2 \phi}. \quad (9)$$

Again, substituting this value of  $x$  in the coefficient of  $dx/da$  in (8), we get

$$a \frac{\cot \phi}{\cos 2\phi} - a \cot \phi \cos 2\phi - h \sin 2\phi,$$

which is nearly equal to  $h \sin 2\phi$ .

It is evident, therefore, that as  $a$  increases through the value  $h(\cos 2\phi)/(\cos^2 \phi)$ , the coefficient of  $dx/da$  remains about equal to  $h \sin 2\phi$ , a positive quantity, while the remainder of equation (8), namely,  $-x \cot \phi \cos 2\phi + a \cot^2 \phi$ , changes from  $-$  to  $+$ , for  $x$  is constant and  $a$  is increasing. Hence,  $dx/da$  changes from  $+$  to  $-$ . Hence  $x$  is a maximum when

$$x = a \frac{\cot \phi}{\cos 2\phi} = \frac{h}{\sin \phi \cos \phi}. \quad \text{by (9)}$$

Also, from (2), we get

$$l = \frac{a}{\sin \phi} = 2h \frac{\cot 2\phi}{\cos \phi}. \quad \text{by (9)}$$

Also solved by O. S. ADAMS and HORACE OLSON.

## NUMBER THEORY.

### 255. Proposed by FRANK IRWIN, University of California.

Given any arithmetical progression whose first term  $a$  and common difference  $d$  are relatively prime integers, and any finite set of positive integers  $m_1, m_2, \dots$  also relatively prime to  $d$ , it is required to determine an integer  $n$  such that the multiples of  $m_1, m_2, \dots$  may occupy the same